VANADIUM CORPORATION OF AMERICA
(VCA) NATURITA MILL
approximately three miles northwest of Naturita,
between Colorado State Highway 141 and
the San Miguel River
Vicinity of Naturita
Montrose County
Colorado

HAER No. CO-81

HAER
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43-NATU.V,
1-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

REDUCED COPIES OF MEASURED DRAWINGS

Historic American Engineering Record
National Park Service
Department of the Interior
Denver, Colorado 80225-0287

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VANADIUM CORPORATION OF AMERICA
NATURITA MILL

Historic American Engineering Record
HAER No. CO-81

Location: In western Montrose County, Colorado, approximately three miles northwest of Naturita, between Colorado State Highway 141 to the southwest, and the San Miguel River to the northeast; in the NW¼ of the SW¼ of Section 14, Township 46 North, Range 16 West.

USGS Quadrangle: Naturita, Colorado 7.5 minute, 1964

UTMs: Zone 12:

Point A.	4,234,710m north	709,075m east
Point B.	4,234,860m north	709,175m east
Point C.	4,234,810m north	709,320m east
Point D.	4,234,610m north	709,230m east

Dates of Construction: 1927, 1947, 1960-61

Present Owner: Cyprus-Amax Minerals Corporation, 9100 E. Mineral Circle, Englewood, CO 80112

Former Owners: Rare Metals Corporation, circa 1927-1935; Vanadium Corporation of America, circa 1935-1967; Foote Mineral Company, 1967-1989; Cyprus Minerals Corporation, 1989-1993

Present Use: Vacant / Not in Use

Significance: From the early 1940s to the end of the Cold War era, the Naturita Mill played a prominent role in national and international events related initially to the U.S. Army's World War II Manhattan Project, and later to the Atomic Energy Commission's efforts to procure and process domestic sources of uranium. Similarly, the mill played a central role in the socioeconomic development of western Montrose County for more than a half century, and it impacted the economic health of the entire Colorado Plateau as well. Following the facility's initial construction in the late 1920s, it was first used to process vanadium. Used as an alloy to strengthen and give steel greater elasticity, vanadium was vital to U.S. war production efforts during World War II. Perhaps of greater significance was the mill's association with the Manhattan Project and with the Atomic Energy Commission's uranium procurement program during the Cold War era. Some of the uranium mined on the Colorado Plateau during World War II was processed here before it was tested by the Army at Grand Junction, Colorado. From Grand Junction, the uranium was shipped east for further processing at Canonsburg, Pennsylvania, and from there to Oak Ridge, Tennessee. Thus it is possible that some uranium processed at the Naturita Mill was used in the atomic weapons dropped on Hiroshima and Nagasaki, Japan in August 1945. Following the war, the Naturita Mill continued to process uranium used in the production of atomic weapons and for the development of nuclear energy. In this regard, the mill was associated with the Colorado Plateau's uranium boom of the 1950s, and it continued to help shape the region's socioeconomic and political character in the post-war era.

Historians: Carl McWilliams, Principal Investigator / Lisa Schoch-Roberts, Historian
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Introduction

The Historic American Engineering Record (HAER) documentation of the Vanadium Corporation of America (VCA) Mill at Naturita was conducted by Andrews and Anderson P.C. of Golden, Colorado, and Cultural Resource Historians, of Fort Collins, Colorado. Undertaken between July and December 1994, the documentation was prepared for the U.S. Department of Energy (DOE) under contract with Jacobs Engineering Group of Albuquerque, New Mexico. The project's purpose was to document the mill site prior to its demolition under the DOE's Uranium Mill Tailings Remedial Action (UMTRA) project at Naturita. The DOE, in consultation with the Colorado Office of Archeology and Historic Preservation, had determined that certain features at the mill site were eligible for inclusion in the National Register of Historic Places. Due to the presence of residual radioactive materials, however, it was determined that these features could not be preserved.

Entailing in-depth archival research, an intensive-level survey, large-format photography, the preparation of measured drawings, and this report, this documentation is intended to fulfill the DOE's obligations under Section 106 of the National Historic Preservation Act of 1966, and Executive Order 11593, as administered by the Colorado Historical Society and the National Park Service.

To prepare this report, research for the project was conducted at the following repositories: the Museum of Western Colorado, the DOE's Grand Junction Projects Office, and Mesa State College Library's Special Collections, in Grand Junction; the Colorado School of Mines Library in Golden; the Colorado Historical Society Library, Denver Public Library's Western History Room, and the Colorado State Archives, in Denver; Colorado State University's Morgan Library in Fort Collins. In addition, oral interviews were conducted with former VCA Naturita Mill employees, Leonard "Pat" Daniels and Alfred "Buddy" Curtis, and with former Atomic Energy Commission, Grand Junction Operations Office employee William L. Chenoweth. Mr. Daniels, Mr. Curtis and Mr. Chenoweth also reviewed and provided written comments on the draft version of this report.

Geologic Overview and Early History of the Colorado Plateau

Encompassing over 100,000 acres of rugged, arid and semi-arid land surrounding the four corners region of Arizona, Utah, Colorado and New Mexico, the Colorado Plateau was once one of America's most isolated locals. Few adequate roads accessed the region, and water sources were often poor, with perennial streams running only sporadically. Not surprisingly, few people endeavored to settle there.[1] Nonetheless, for all its desolation the Colorado Plateau enjoyed steady mining activity throughout much of the twentieth century. Less glamorous than Colorado's gold and silver rushes, mining for radium, vanadium and uranium was often as profitable as gold and silver, and was influential in shaping the western slope's economy and social character. On a larger scale, this mining activity placed the western slope at the heart of the nation's Atomic Age.

The geology of the Colorado Plateau consists primarily of sedimentary rocks from 5,000 to 20,000 feet thick.[2] Included among these sedimentary layers are the Morrison formation, the Entrada sandstone, and the Chinle formation, all of which contain primary deposits of vanadium, uranium and radium.[3] These deposits are commonly referred to as "carnotite deposits," and are found primarily in sandstone, mudstone, conglomerates and limestone.[4] The sandstone is usually red, brown, or buff in color, while the color of mudstone varies. Uranium minerals are found in association with carbonaceous deposits in the sedimentary beds. Located in "irregular, tabular, or lens-shaped masses," most carnotite ore[5] bodies generally parallel the bedding patterns of the sedimentary rocks, although they do not mimic these patterns completely.[6] Prevalent in the terrain of the Colorado Plateau are sheer canyon walls and plateaus, which provide ample outcrops that often lead to mining discoveries.[7]

The Colorado Plateau's earliest communities developed late in the nineteenth century. Originally based on farming and cattle ranching, these communities would eventually play an important role in the western slope's vanadium and uranium industries. Naturita and Nucla, both located in the San Miguel Basin east of Paradox Valley, developed in the late 1880s and 1890s.[8] The first cabin in Naturita was built by Payson Blake, who had been running cattle through the area since the 1870s.[9] Payson and his two brothers, Mesrole and Rockford, had originally come to Denver for the gold rush, but when narrow gauge railroads reached Gunnison, they headed for the western slope. Mesrole Blake landed a mail contract from Gunnison to Ouray that eventually extended to Naturita. Rockford Blake lived in Rico until 1879, when a hard winter and news of placer mining on the San Miguel River convinced him to move his family to the Naturita area in 1882. There he built a cabin, constructed a road at the mouth of Hank's Valley and became the town's first postmaster.[10] Rockford's wife named the town Naturita or "Little Nature" in Spanish. She was a great nature lover, and felt that the San Miguel River created a striking contrast to the desolate landscape surrounding it.[11] Soon after the Blakes settled in Naturita, other families moved to the area. By the turn of the century there were enough residents within a 30 to 40 mile radius to organize social events. By 1900, interest in mining was also developing, as the town became a regular stop for freight wagons transporting copper ore from the Cashin Mine near Bedrock to the Placerville railroad.[12]

Nucla was formed by the Colorado Cooperative Company, a Denver ditch company interested in organizing a colony for its members. Hoping to create a Utopian community based on "equality and service" rather than private ownership, the company in 1894 selected a site near Tabeguache Park, north of Naturita in the San Miguel Basin.[13] The 20,000-acre site contained fertile soils, but was very arid. As a result, residents of the new community leased 80 acres of land below Naturita on Naturita Creek from Rockford Blake in exchange for building a water ditch for him. After several years, the community moved to a narrow strip of land containing 15 to 20 acres in the bottom of San Miguel Canyon. There they established the town of Pinon, which by 1901 had 50 buildings and its own newspaper, the *Alturian*.[14] It took ten years to complete the ditch. By that time, the community was in search of a new name. Feeling that it "formed the nucleus of a socialistic community," the residents named their town Nucla, from the word "nucleus." Not long after, residents became more interested in private ownership, and the Utopian experiment disintegrated.[15]

Other Paradox Valley and San Miguel Basin communities were also influenced by mining. The earliest major ore deposits during the radium years were located at the San Miguel Cattle Company, Long Park, Bull Canyon, and on the Monogram Mesa. Headquarters for the San Miguel Cattle Company, also known as the Club Ranch, were located fifteen miles west of Naturita along the San Miguel River. Comprised of 110 acres of hay land, the ranch was located at the present site of Uravan. Long Park was seven miles southeast of present day Uravan, while Bull Canyon was accessible by a trail in the southern part of Paradox Valley. Despite the prevalence of mining, most of these communities were only indirectly influenced by the industry. Boom money certainly helped the communities, but the agricultural lifestyle of most permanent residents was retained during the early years of radium mining.[16]

The Radium Era on the Colorado Plateau 1898 - 1923

The discovery of radium-bearing carnotite ore launched the first mining activity on the Colorado Plateau beginning just prior to the turn of the century. Considered a secondary mineral, carnotite is classed as a potassium uranium vanadate. Yellow in color, carnotite was reportedly used by the Ute Indians as a clothing dye and as a facial paint prior to 1880.[17] In 1881, prospector Tom Talbert mined some of the yellow substance along Roc Creek in western Montrose County. He sent a sample to an assayer in Leadville, who subsequently failed to identify it. Another prospector, Tom Dullan, rediscovered Talbert's Roc Creek finds, but also failed to profit from it. Eventually, in 1898, Ouray resident Gordon Kimball shipped nine tons of the material to chemist Charles Poulot in Denver.[18] Kimball thought he had discovered a type of copper ore, but he instead learned that the material contained levels of uranium high enough to be valuable for their radium content. In 1899 Poulot sent samples of the ore to France, where French scientists named it for mining engineer and chemist M. Adolphe Carnot.

The discovery of radium by Marie and Pierre Curie in 1898 revealed that all uranium ores contained radium. Medical doctors subsequently discovered that radium was effective in treating certain types of cancer.[19] Thus, with a demand for radium established by the medical community, an incentive to mine carnotite ore that contained radium was created.[20] The discovery that radium compounds glowed in the dark opened radium production to other markets as well. Processed into a luminous paint, radium was used to produce luminous watch dials and other instruments. During World War I, luminous dials were used on rifle scopes and on other weapons and machinery, that for the first time allowed soldiers to see and calibrate them in the dark without the need for an external light source.

Carnotite mining companies were formed in southwestern Colorado as early as 1900. At that time, Charles Poulot and Charles Voilleque established a camp and laboratory at the Cashin mine and mill, near the La Sal River, to extract vanadium and uranium oxides from carnotite. Establishing a company with a third partner, James McBride, they built an experimental mill at the mouth of Summit Creek near Slick Rock. Before they turned the company over to the Western Refining Company in 1903 and the Dolores Refining Company in 1904, the mill processed 15,000 pounds of uranium-vanadium concentrates. This venture brought about an enormous interest in claim-staking between 1902 and 1905. Over a broader period of time, between 1898 and 1909, nearly 9,000 tons of high-grade radium bearing ore were produced in the region. The majority of this ore was then shipped to the eastern United States or to Europe for radium extraction.[21]

By 1910, metallurgical processes for the recovery of radium from carnotite ore had been perfected. This led to an increased demand for the product, which, in turn, caused a significant increase in carnotite mining on the Colorado Plateau. The creation of the National Radium Institute (NRI) in October 1913 was another factor that spurred the mining industry on the Colorado Plateau. A cooperative undertaking between the U.S. Bureau of Mines and private industry, the NRI worked to enhance radium extraction techniques and to disseminate technical information to producers and users of radium. The Institute closed in 1916, having produced 8.5 grams of radium from 1600 tons of ore.[22]

By the 1910s the Colorado Plateau's carnotite deposits had become one of the world's chief sources of radium.[23] The radium mining years brought an influx of industry to the region. Both individual prospectors and large companies profited from the radium boom. Not long after carnotite was found to be a valuable source of radium, claims were staked along Roc Creek, La Sal Creek and nearby regions. The richest carnotite mines were along the north and south rims of the Paradox Valley, located in western Montrose County. In this area carnotite deposits were prevalent in the Salt Wash Member of the Morrison Formation. Three cliffs comprised the sandstone of the Salt Wash in the Paradox Valley. Ore deposits were generally found in the upper sandstone beds - referred to as "the third rim" - with the most concentrated ore deposits appearing in "sharply bounded, elongate concretionary structures, called 'rolls' by the miners."[24]

Mining methods varied, depending on whether an individual prospector or a company was involved. Large companies, for instance, used jackhammers, a tool rarely afforded by the individual miner. Powered by compressed air from a gasoline generated compressor, jackhammers drilled as far down as 30 feet to locate deposits. Ore was recognized by the color of the dust on the drill bits. In underground mines, ore cars were moved by animals or men, while gasoline-powered hoists were used to pull the cars up steep inclines.[25] After the ore was transported to the plants, radium was extracted from the carnotite ore through a chemical process.[26]

Between 1910 and 1922, several mining companies either located in or acquired claims in various parts of southwestern Colorado. One of the largest, the Standard Chemical Company of Pittsburgh, Pennsylvania, reportedly came to Montrose County after a Texas cowboy named Jake Hart discovered carnotite ore near Naturita.[27] Established by three brothers--Joseph, James and John Flannery--in 1910, Standard Chemical eventually became one of the region's most prolific producers of radium ore. The Flannerys already operated the American Vanadium Company, which mined vanadium in Peru.[28] The company established its headquarters at the Coke Ovens approximately four miles west of Naturita.[29]

Active between 1912 and 1921, Standard usually shipped very high-grade ore--greater than two percent radium--to its plant in Canonsburg, Pennsylvania. From 1912 through 1914, the company operated a dry-processed concentrator along the San Miguel River at the present site of Uravan. Dry processing involved using compressed air to isolate the carnotite from sand particles. The company changed its operation to a wet concentration process in 1914 and expanded its facility, which was known as the Joe Junior Mill. The company had mines in both Montrose and San Miguel counties; by 1918 it had 375 claims in the Paradox Valley region. Near the end of the radium boom in 1918, Standard employed 200 men in its southwestern Colorado plants. The company ultimately produced 74 grams of radium, roughly 47% of the country's entire domestic radium production.[30]

Though not as successful as Standard Chemical, other companies ran short-lived radium operations on the Colorado Plateau and across the United States. In 1914, Dr. W.A. Schlesinger began operating a radium refining laboratory at Princeton University. By 1915, the Schlesinger Radium Company had built a radium reduction plant in Denver and accumulated carnotite claims in Montrose County. The company became the Radium Company of Colorado in 1917, acquiring forty claims in Long Park and Gypsum Valley of Montrose County. In 1921 Tungsten Products Company of Boulder - which had recently purchased the Colorado and Utah claims of the declining Carnotite Reduction Company of Chicago - merged with the Radium Company of Colorado. Eventually, the Radium Company of Colorado became the second largest radium producer behind Standard Chemical, producing 45 grams of radium between 1915 and 1921.[31]

The third largest domestic producer of radium was the Radium Luminous Material Corporation, which was formed in 1914 in Newark, New Jersey, by Sabin A. von Sochocky. von Sochocky had been one of the first to use luminous paints from radium on clocks and watches. The company's principal claims were at Long Park, but it also acquired some in Montrose County's La Sal Creek, Silvey's Pocket, and Roc Creek regions. By 1921, the company had become the U.S. Radium Corporation. It existed in Montrose County until 1923, by which time it had produced some 30 grams of radium.[32]

The advent of World War I in 1914 did not significantly affect demand for radium within the United States, but it did disrupt European radium markets. Increased demands for vanadium - another carnotite by-product - began at this time. Used as an alloy to give steel greater tensile strength and elasticity, vanadium was critical to war production efforts during both world wars. Thus, by the time that the United States entered World War I in 1917, a gradual shift from radium extraction to vanadium extraction had already begun. The end of the war in 1918 caused a drop in the demand for vanadium, while the radium market continued to remain sluggish.

On the Colorado Plateau, the radium era's death knell came in 1922 with the discovery of high-grade, radium-bearing, pitchblende ores in the Belgian Congo (now Zaire). Offering a much lower yield of radium, carnotite ores on the Colorado Plateau could not compete with the rich new African discoveries. Consequently, by 1923, the mining of carnotite for radium on the Colorado Plateau had basically ended.[33] Although a few companies continued with domestic radium production for a few more years, for all practical purposes, the Colorado Plateau's radium boom was over.

Vanadium Production on the Colorado Plateau 1900 - 1942

Although radium extraction dominated the Colorado Plateau's mining industry from the late 1890s to the early 1920s, the importance of vanadium slowly emerged during these years as well. Scientists had been aware of vanadium since 1801, when M. Del Rio discovered it in what later became known as Vanadinite, a lead chloro-vanadate. In 1830, H.G. Sefstrom named it after the Scandinavian Goddess of Beauty - Vanadis. Sefstrom was also the first to extract vanadium from iron slag. Vanadium's importance in strengthening steel was not recognized until 1896, however, and it was not until 1905 that the discovery of rich Peruvian deposits of vanadium enabled its more widespread use as a steel alloy.[34]

Companies with specific interests in vanadium gradually were incorporated.[35] Shortly after the first vanadium deposits were found in western Montrose County in 1900, the U.S. Vanadium Company bought claims and constructed a mill at what was then known as Newmire.[36] The Vanadium Alloys Company, the American Vanadium Company, the Primos Chemical Company, and the Electro-Metallurgical Company, all became involved in vanadium production prior to 1910. Also, in 1909, the Rare Metals Mining and Milling Company bought mining claims from individual holders. At the same time, the Primos Chemical Company of Primos, Pennsylvania invested in the U.S. Vanadium Company and constructed a 100-ton capacity mill at Vanadium. The mill was destroyed by fire in 1919.[37]

Vanadium production in the United States continued to evolve during the 1910s. Production during this period peaked during the war years, as the United States' involvement in World War I created a strong demand for vanadium.[38] By 1913, the total U.S. production of vanadium equalled 412 tons. Other companies that began to produce vanadium in the 1910s included Arden Wilson & Company, Colorado Carnotite Company, General Vanadium Company, McKeever & Company, and Standard Chemical. In 1919, the Flannery-owned Vanadium Company of America was sold to the Vanadium Corporation of America (VCA), which was headed by Charles M. Schwab and J.L. Replogle.[39] VCA had been incorporated specifically to acquire vanadium businesses and properties. The corporation's main offices were in New York, but it soon became heavily involved in Colorado's mining industry.[40] In 1920, VCA acquired all of Primos Chemical Company's vanadium, molybdenum and tungsten mines in Colorado.[41]

The vanadium market declined during much of the 1920s. In part, the drop in demand had been caused by the conclusion of the war in 1918, but interest in vanadium by the steel industry was weak generally in the post-war years.[42] In 1928, only the United States Vanadium Corporation (USVC) was producing vanadium.[43] A subsidiary of Union Carbide and Carbon Corporation, USVC was banking on the return of a strong vanadium market. The company was not disappointed. Colorado's vanadium industry enjoyed steady growth after the mid-1930s. Most of the mines that had closed at the end of the radium boom were reopened by 1935, and several companies improved their facilities. By 1935, the USVC had bought out Standard Chemical's Joe Junior concentrator, and had altered the metallurgical process to handle carnotite ore at the rate of 240 tons per day. The following year, the townsite of Uravan was founded.[44]

After the Rare Metals Corporation of America was incorporated in 1927 it began efforts to build a vanadium processing mill west of Naturita.[45] Three years later, Rare Metals mortgaged its Montrose County properties to the VCA.[46] During this period, VCA was continuing to expand its Colorado interests, eventually procuring nearly 300 claims in San Miguel and Montrose counties, and in San Juan County, Utah.[47] Between 1934 and 1935, VCA secured the assets of the Colorado Radium Company and the U.S. Radium Corporation, and also acquired the vanadium mill at Naturita. In the ensuing years, VCA fixed up the old Rare Metals mill, so that by 1939 it was fully operational as a vanadium processing plant. The VCA also established a company town named Vancoram (A name composed from *Van*adium *Cor*poration of *Am*erica)just west of Naturita.[48] By 1940, the Naturita Mill was producing 100 tons of vanadium per day.[49]

Ore processed in the Naturita Mill was taken primarily from VCA's holdings in Montrose and San Miguel Counties, but some was also purchased from individual miners and leasers.[50]

The vanadium industry expanded further following the United States' entry into World War II.[51] Vanadium was regarded as a strategic metal, and thus to promote its production, the federal government created the Metals Reserve Company in 1942. In an effort to provide incentive for vanadium mining, Metals Reserve increased the price of vanadium ores and then began to buy them. VCA and USVC-operated mills at Monticello, Utah and Durango, Colorado were built by Metals Reserve. Working in conjunction with USVC, Metals Reserve also assembled buying stations to ensure that the mills would be used to capacity.[52] The U.S. Bureau of Mines also endeavored to increase levels of vanadium production in 1942. Through exploratory core drilling and sampling, the Bureau worked with the United States Geological Survey to "increase the known reserves" in various claims and mines.[53]

In February 1944, as the war began to wind down, Metals Reserve was closed, and soon thereafter many vanadium mines shut down and the mills decreased their production levels accordingly. In the meantime, the war had spawned efforts to extract another material from the carnotite ore found on the Colorado Plateau. This material was uranium and its procurement was critical to the development of the first atomic weapons.

The Manhattan Project 1942-1945

In August 1942, the U.S. Army Corps of Engineers established the Manhattan Engineer District (MED) to develop atomic weapons, and concomitantly to procure the raw materials - principally uranium - necessary for their production.[54] Given the code name "Manhattan Project," these undertakings had a profound impact on the uranium industry on the Colorado Plateau. In June 1943, the army established the "Murray Hill Area" as a division of the MED responsible for the exploration and development of raw materials necessary to build atomic weapons.[55] At that time, the largest known sources of uranium were the Shinkolobwe Mine in the Belgian Congo, (Zaire) and the Eldorado Mine on Great Bear Lake in Canada's Northwest Territories. In the United States, though, uranium was also known to exist in the carnotite deposits in the Morrison Formation on the Colorado Plateau.[56]

Efforts to locate uranium on the Colorado Plateau were particularly significant because the MED believed that it was critical to develop a domestic uranium supply. Consequently, the MED contracted with the nation's two largest vanadium producers - the U.S. Vanadium Corporation (USVC, owned by Union Carbide) and the Vanadium Corporation of America - to procure and process uranium bearing ore.[57] To facilitate the process and to provide financial backing, the federal government's Metals Reserve Company fostered efforts to procure uranium as well as vanadium.[58] In addition, the MED established the Union Mines Development Corporation (UMDC) as a Union Carbide subsidiary. UMDC was ostensibly established as a private international mining company interested in tungsten, molybdenum and vanadium. The company's true purpose, though, was to facilitate the procurement and development of uranium for use in atomic weapons.[59]

UMDC offices were set up downtown Grand Junction, in the First National Bank Building. Staffed by geologists, engineers, chemists, and other scientists, this office secretly coordinated uranium development efforts on the Colorado Plateau. These efforts initially involved converting vanadium producing mills to uranium production as well. Moreover, efforts early on were directed at reprocessing old vanadium tailings for their uranium value. In March 1943, Army Lieutenant Philip Leahy was stationed at Grand Junction to administer the Manhattan Project's domestic uranium procurement program. Leahy directed the transition from vanadium to uranium *and* vanadium production in several mills, including the Metal Reserve's USVC-operated Durango Mill, USVC's Uravan Mill, Metal Reserve's VCA-operated mill at Montecillo, Utah, and VCA's mill at Naturita.[60] Leahy's directive was to ensure that the mills produced as much uranium as possible.[61] He was also in charge of securing property in Grand Junction for a uranium refinery. Eventually a 55.71-acre parcel of land located between the Gunnison River and the Denver and Rio Grande Railroad was leased, and later purchased by the federal government for this purpose. USVC was contracted by MED to have the refinery constructed. Stearns-Roger, an engineering and manufacturing firm, prepared plans for and built a refinery that would concentrate uranium and extract the vanadium from the "green sludge"[62] produced at Uravan and Durango.[63] Leahy later indicated that he had no real understanding of the uranium procurement project's ultimate goal. He stated that "the MED policy was to supply a person with only the information needed to accomplish the assigned work," and it was only with hindsight, many years later, that he fully understood the purpose of his work.[64]

The treatment plants for reprocessing uranium-bearing tailings were constructed in Durango and Uravan in 1943. Tailings from the Naturita and other mills were transported to Uravan where they were processed into the green sludge that was eventually processed in the Grand Junction refinery to yellowcake - or uranium concentrate. By the end of the war in 1945, these facilities had reprocessed three million tons of tailings.[65] Nearly 66 percent of the domestic supply of uranium used in the Manhattan Project came from Uravan and Durango, 17 percent came from Naturita, and smaller amounts from other sources. All together, these percentages constituted only 14 percent of the total amount of uranium used in the Manhattan Project; the remainder came from the Belgian Congo and from Canada.[66]

The Role of the VCA Naturita Mill in the Manhattan Project

Located approximately three miles northwest of Naturita on the San Miguel River, the Naturita Mill was ideally situated for processing uranium and vanadium ore. It was close to the ore supply, had a good source of water, and a coal mine to furnish power.[67] When it was first constructed by Rare Metals in the late 1920s, the Naturita Mill was used only intermittently. After VCA rebuilt it in the mid-1930s, however, the mill began processing vanadium on a regular basis in 1939.[68] During the war, to fulfill its contract with the MED, VCA began efforts to add a "uranium circuit"[69] to the mill so that it could process both vanadium and uranium. Before the uranium circuit was in place, however, the MED arranged to purchase existing tailings at Naturita that had already been processed for their vanadium values. These tailings were trucked to Uravan where they were processed for their uranium values by the USVC.[70] Eventually, a uranium circuit was placed in the Naturita Mill so that it could process uranium on its own.[71]

By 1945, when MED's business in Grand Junction and the Colorado Plateau was drawing to a close, the Naturita Mill site consisted of crushing bins for coarse and fine materials, drying and roasting buildings as well as structures for leaching and precipitation. Storehouses, vehicle repair shops, blacksmith shops, a pumping station, cooling pond, and a laboratory completed the site. All the structures were constructed of wood, except for the roaster units.[72] Earlier, a variety of buildings were built on or moved to the site. One of the roasters and a warehouse were built by Rare Metals in 1927, and two warehouses were built in the late 1930s, most likely by the VCA.[73]

The Manhattan Project, of course, led to a quick and decisive end to the war in August 1945. And as a key part of the Manhattan Project, uranium development efforts on the Colorado Plateau had a profound effect on the region's mining industry and clearly impacted the area's socioeconomic development as well.

The Uranium Boom and the Naturita Mill 1947 - 1958

In 1947 a new phase of uranium mining began on the Colorado Plateau. Although World War II had ended, the advent of the Cold War meant that efforts to procure uranium for nuclear weapons would continue. In addition, the federal government also began to look at uranium for peaceful uses.[74] In the early 1950s, it was estimated that one pound of uranium had the power equivalent to 1300 pounds of coal, more energy than 350,000 gallons of gasoline, and the horsepower of 2,500,000 kilowatt hours of electricity.[75] Peacetime uses for atomic energy were, of course, promoted by the uranium industry. One development was the experimental breeder reactor, essentially a furnace powered by uranium fuel. When uranium was bombarded with neutrons, fission of that atom occurred and created an enormous release of heat and energy. Physicists stated in 1955 that atomic power reactors could create "superheat" that would lower heating bills and would allow merchant ships to operate on a non-stop basis. Atomic-electricity cities and nuclear-propelled airplanes were also possible with the "never-ending source of power" - the reactor.[76]

The Atomic Energy Commission (AEC) was at the helm of the uranium boom.[77] In 1947 the AEC created separate Exploration Branches and Raw Materials Offices, which administered AEC's domestic uranium program.[78] The Raw Materials Office and Exploration Branch combined in 1952 to form the Grand Junction Operations Office, which functioned as the administrative headquarters for the U.S. Atomic Energy Commission.[79] Its responsibilities included the development of uranium mining and procurement in every state west of the Mississippi. Located on the 55-acre tract of land at the site of the old MED refinery, the Grand Junction Operations Office or "AEC compound" was a high-security site consisting of thirty-five buildings.[80] Grand Junction was considered an ideal location for the operations office for both economic and strategic reasons. Any significant points in the region could easily be reached by car within a few hours, and the AEC compound included service and operating divisions, offices of the United States Geological Survey and four different contractors.[81]

Between 1947 and 1971, the AEC continued the uranium procurement program originally begun under the MED during World War II. AEC purchased the uranium from private companies primarily for use in the manufacture of nuclear weapons. In addition, though, the Atomic Energy Acts of 1946 and 1954 were passed to ensure that the uranium procurement program also reflected the growing interest in peaceful uses of atomic energy.[82] In 1948, AEC launched a domestic procurement program specifically structured to revive prospecting and to enhance the uranium mining industry. Companies interested in contracting with AEC were required to provide a prospectus indicating their ability to match the AEC's ore supply levels. The companies also had to prove that they were technically and financially capable of fulfilling the AEC's requirements. Once this was accomplished, the contracts included a variety of conditions: companies would convey the entirety of their mill production to AEC and companies had to purchase ore from independent ore producers. Other conditions depended on the company.[83] The AEC had effectively cornered the market on uranium mining and production. While private companies mined and processed the uranium ores, the AEC provided geologic surveys, free testing, and assaying. In addition, AEC assured a steady market by establishing purchasing schedules and incentives.[84]

The AEC, in association with the U.S. Geological Survey, also conducted extensive exploratory missions on the Colorado Plateau between 1946 and 1958. In all, some 700 square miles of the public domain were withdrawn for survey. Results of surveys were published for the benefit of private companies and individual prospectors. Eventually, if no ores were found, the lands were returned to the public domain.[85]

During these years, the AEC's procurement program resulted in an unprecedented mining boom that created a virtual mining subculture in the communities of the Colorado Plateau. Once confined to private companies or experienced miners, the mining industry now appealed to the general public. People who had never mined or even been to the West were suddenly caught up in the boom. Magazine and newspaper articles outlined get-rich-quick mining techniques.[86] The basic necessities for uranium mining - the jeep, trailer, and geiger counter - were advertised everywhere. Companies that specialized in uranium mining equipment popped up. Grand Junction experienced a social revolution centered around the mining industry. Anyone could strike it rich. The boom was on.

Thousands of professional and amateur miners poured onto the Colorado Plateau. In every facet of the mining industry, statistics increased exponentially. While there were about 200 geologists surveying the area in the late 1940s, by 1955 there were at least 1500. In 1953, 250 people had staked claims, but by 1955 claims had been staked by 1000 people.[87] The media helped to perpetuate these increased numbers. In a 1955 cover story, *Life Magazine* called the uranium boom "History's Greatest Metal Hunt" and featured a photograph of "students of uranium prospecting course at Colorado's Mesa Junior College" (now Mesa State College). The magazine article also presented a "basic guide to the amateur uranium seeker" and described "the most and the minimum in prospecting equipment."[88]

The *Life Magazine* article, and other publications, attracted numerous amateur miners interested in adventure and in making a profit. Included among the equipment were four-wheel drive jeeps, scintillation counters, assay kits, geiger counters, ore picks, measuring tapes, and radiation counters. The uranium equipment business that supplied these items developed as the boom intensified. Precision Radiation Instruments of Los Angeles, and Chicago's Nuclear Instrument and Chemical Corporation were just two of the many companies that manufactured radiation counters. Other well-known companies such as Montgomery Ward and Sears Roebuck and Company also featured geiger and scintillation counters.[89] Professional organizations, including the Uranium Ore Producers Association, published monthly journals about the uranium industry.[90] R & W Trailer Sales in Grand Junction advertised an entire line of "trailers for the mining industry."[91]

A striking result of the mining boom was a sharp increase in population throughout the Colorado Plateau. Once considered "a Colorado orphan," Grand Junction became the hub of the uranium mining boom.[92] From a population of 10,247 in 1945, the city grew to just under 30,000 residents in the early 1950s.[93] Other communities also experienced sharp increases in population. Uravan grew from 800 inhabitants in 1952 to 1500 in 1955.[94] Grand Junction and Uravan both handled the increased population fairly easily. Plans for growth were well in place in Grand Junction. Owned by U.S. Vanadium, Uravan had no problem providing housing, a sewage system, recreational facilities and other public services as the need arose. Other communities found it more difficult to accommodate the increased populations. Nucla and Naturita, for instance, fought to acquire financing for housing, and decent water and sewage systems.[95]

Having experienced booms and busts since radium was discovered in the late 1890s, Naturita was eager to benefit from the uranium boom. Between 1939 and 1954, its population grew from 39 to 1200. The Vanadium Corporation of America was largely responsible for the most recent stretch of stability in Naturita. Its Naturita Mill employed 100 men, and the Vancoram Housing Project continued to accommodate miners. Yet, Naturita's school needed to expand, and the town still needed a decent road system.[96] By 1955, other elements of Naturita had grown. New businesses, a self-service market, gas station, hotel, bar, restaurant, drilling company, trailer courts and a theater, all resulted from the boom.[97]

The VCA's Naturita Mill was also an integral part of the uranium boom throughout the 1950s. In 1947, VCA became the first company to enter into a contract with the AEC for the processing of its vanadium and uranium ores. The contract extended from August 1947 to July 1949 and consisted of a series of articles that addressed the following items: weighing, sampling and assaying, delivery and acceptance, packaging, and payments.[98] Modifications on this contract extended its term to 1958. Throughout these years, the AEC purchased the uranium concentrate delivered under contract. Moreover, in the post-war years the vanadium market became soft, so VCA sold its surplus vanadium concentrate to the AEC for $.98475 per pound.[99]

Throughout the uranium boom VCA owned and operated the Naturita Mill. In 1950 the company reported its net sales at $29,320,874, a 67% increase over the 1949 figure of $17,592,312. The company's production of grades of ferro-chromium, ferro-vanadium, ferro-silicon, and vanadium pentoxide in 1950 contributed to 77% of its total net sales. While VCA sold its uranium and vanadium to the U.S. Government exclusively, they sold their other products to steel companies, iron foundries, the aluminum industry, and chemical, ceramics and glass companies. These other products were sold under the name Vancoram, a shortened version of Vanadium Corporation of America. At that time, VCA owned plants in Niagara, New York, and Bridgeville, Pennsylvania. It also owned the Rhodesian Vanadium Corporation in southern Rhodesia and a division in Peru. The company made plans in 1950 to expand its Niagara facilities and to construct a plant in West Virginia. VCA attributed its 1950 increase in net sales to its western holdings as well.[100]

The company was prosperous through 1956. In May 1951, VCA acquired a lease from T.C. and Henry Brammier and Associates for forty-one mining claims throughout an 800-acre area in the Long Park area of Montrose County. Included in the lease were uranium-vanadium ore reserves "for milling at nearby Naturita Mill."[101] In 1953, VCA made some significant changes to its Colorado Plateau holdings. It purchased the Durango Mill, which it had previously leased from the AEC, and it installed additional roasters and equipment at both the Durango and Naturita mills.

In 1955, VCA completed an expansion of the Naturita Mill increasing its production capacity to 200 tons per day.[102] A year later, the mill was processing 325 tons per day.[103] In 1956, with the end of the boom not yet in sight, the tonnage of vanadium-uranium ores mined and milled on the Colorado Plateau continued to increase, and the VCA purchased 1/3 interest in twenty-seven mining claims extending over a 550-acre area near the Naturita Mill. Located in the Long Park area of the Colorado Plateau, these claims were known as the Eagle Basin Group.[104]

The end of the boom came all too quickly, however. In 1957 events transpired that ultimately resulted in the Naturita Mill's closure in February 1958. Noting that a recent recession had brought about a drop in the capital goods market, VCA stated in its 1957 annual report that its sales had been "restricted temporarily."[105] While mill production had increased, actual earnings on AEC sales had decreased. The drop in earnings had resulted from an agreement that VCA and AEC had reached when their contract expired in June 1957. After its closure as part of a consolidation effort, operations at the Naturita Mill were transferred to the VCA's Durango Mill.

VCA's problems deepened. The recession, decreased steel production, AEC's reduced prices, and difficulties with the Durango Mill all had a significant impact on the company. Although VCA received a new contract to expand the Durango Mill, the AEC had instituted a price reduction for all concentrates produced at the Durango Mill between 1958 and 1962.[106] Also, in the late 1950s, the Vancoram Housing Project had been sold off at auction.[107]

In May 1958 the AEC announced that domestic producers of uranium ores could now sell their products to buyers interested in peaceful uses for atomic energy.[108] Despite the guarantee of a market through 1966, the AEC later reneged, as reports of increases in ore reserves and milling capacity induced the agency to announce that "it no longer is in the interest of the Government to expand production of uranium concentrate."[109] Subsequently, the AEC modified its procurement program by stating that between 1962 and 1966 it would only buy concentrates from "ore reserves developed prior to November 24, 1958."[110] With this announcement, the uranium boom on the Colorado Plateau was essentially over.

Vanadium and Uranium Processing at the Naturita Mill 1947 - 1958[111]

The millfeed in the Naturita Mill was comprised of uranium and vanadium bearing carnotite ore from mines in the Uravan mineral belt in western Colorado, southeastern Utah, and northeastern Arizona.[112] Fifty-one percent of the millfeed was supplied through contractor-controlled properties, while 49 percent came from independent producers, including those leasing from the AEC.[113]

Between 1939 and 1947 VCA's Naturita Mill processed ore only for its vanadium value, because both vanadium *and* uranium circuits were not in place until 1947. Between 1942 and circa 1947, however, tailings from the Naturita Mill were purchased from VCA by the AEC and trucked to Uravan. At Uravan, these tailings were milled by the United States Vanadium Corporation (VCA's chief competitor) and milled for their uranium values. Then, in 1947, the VCA began to process both uranium and vanadium at the Naturita Mill. The uranium was sold to the AEC for use in the atomic weapons program, while the vanadium continued to be shipped by rail to the eastern United States where it was utilized as an alloy in the manufacture of steel.

Processing the ore for its uranium and vanadium values involved a series of steps that included weighing, crushing, stockpiling, grinding, roasting, quenching and precipitating the final uranium and vanadium products. When the ore arrived at the mill it was allotted a serial number identifying who produced it and where it had been mined. It was then shoveled into stockpiles to await processing. Ten percent of the ore from each stockpile was then shoveled into ore bins where it was blended to the proper consistency.[114] Next, the ore was drawn from the bottom of the bins into a jaw crusher which reduced the ore to minus ½-inch mesh.[115] This crushed material was then stockpiled in another series of bins, before it was fed into a rod mill that pulverized the ore.[116] After it was pulverized, the ore was screened, and any oversized material was again put through the rod mill. This finely ground ore was then put in storage bins to await the roasting process.

In the 1950s, when production was at its peak, there were four roasters at the Naturita Mill. One of the roasters had been built on site by the Rare Metals Corporation in 1927, while the other three had all been moved to the site from other locations. One roaster was brought to Naturita from Dry Valley, Utah in 1947; another was obtained from the Bear Creek Mines and Mill, near Telluride, Colorado, in the early 1950s; and the last roaster was obtained from a mill near Sparks, Nevada, also in the early 1950s. Two of the roasters--those that had come from Nevada, and near Telluride--were moved to VCA's Durango Mill in 1958.

The roasters ranged from approximately 17 to 20 feet in diameter, and were between 30 and 34 feet in height. Their walls were built of fire brick, and one had an exterior steel shell. Each roaster had six levels (called "hearths"), separated from each other by brick partitions. A hollow steel shaft ran vertically through the center of each roaster, and within each hearth, two steel "roaster arms" were screwed into the center shaft. A series of raffles[117] (essentially steel paddles) were attached to the roaster arms, and together, the roaster arms and raffles revolved, raking, or raffling, the ore.

The ore was mixed with three percent iron pyrite. Then, before it was placed in the top of the roaster, the ore was mixed with seven percent salt. In the top hearth, the ore was raffled toward the roaster's middle, to an opening surrounding the center shaft, where it dropped down to the next hearth. In the second hearth, the ore was raffled outward to an opening at the roaster's perimeter. In the third hearth the ore was raffled back to the center, in the fourth hearth back to the perimeter, and so forth. As it passed through each hearth, the ore was roasted, eventually reaching a temperature of approximately 1500 degrees fahrenheit in the lowest hearth. To prevent the roaster's metal components from overheating, a high pressure blower was used to blow cool air through the hollow center shaft and roaster arms. In the 1940s, the roasters were fired by coal that was mined on the hillside across the river from the mill. In later years, the roasters were fueled by crude oil, propane, and finally natural gas.

The raffling process served to keep the ore in continuous motion, ensuring that it was uniformly exposed to the increasing temperatures. The overall purpose of the roasting operation was to create a chloride gas that resulted from subjecting the ore, salt and iron pyrite mixture to the intense heat in the roaster.

When the ore came out of the roaster it was in the form of hot sand. This material was placed in quench tanks, approximately six feet in diameter and eight feet deep, with a filter mat in the bottom. Here, the ore was agitated with a solution of five percent soda ash. Next, the quenched ore was pumped to the leach section, where it entered large, 20-feet diameter by 12-feet deep, tanks. Here, the quenched ore percolated through a filter mat in the bottom of the tank, a process that took from 24 to 36 hours. When the quenching process was finished, a sludge like substance remained in the tanks, which was routed to the tailings pile. The liquid that passed through the filter mat contained both the uranium and vanadium values. Now referred to as a "high grade liquor" this material was pumped to the "A-Liquor" storage tanks.

Also known as an "acid crack," the quenching and leaching processes served to separate (or crack) the uranium and vanadium from the outside of each sand particle. This separation was caused by a chemical reaction between the chloride gas that had been created in the roasting process and by quenching and agitating the ore with the soda ash solution.

From the A-Liquor storage tanks, the high grade liquor was pumped to the uranium purification section where the uranium was largely separated from the vanadium and other insolubles. Here, the liquor was heated and mixed with acid until a nearly neutral Ph was attained. This liquor was then pumped through filter presses, and at this point, the uranium precipitated out into a soluble substance called "yellow cake." Consequently, the filtered liquor that passed through the filter presses still included the vanadium values, but no uranium values.

The uranium, or yellow cake, was then taken out of the presses and put in a drying oven. After it was dried, it was mixed with soda ash, sawdust and salt and was placed in a fusion[118] furnace.

Once it became molten, the liquid was drained into a water-cooled pan causing the fused liquid to turn into a solid, brittle, material. This material was placed in an agitator tank where it was again dissolved. Finally, this material was pumped into a large filter tank with an extremely fine filter mat. The material that failed to pass through the filter mat was ~95 percent pure uranium. The remaining four percent were insolubles including vanadium, copper and lime, which were then pumped to the vanadium precipitation section to extract the vanadium. The uranium was then packed into 55 gallon steel drums and shipped to the AEC in Grand Junction by truck.

In the meantime, the vanadium and other insolubles still present in the filtered "high grade" liquor were pumped to the vanadium precipitation section where it was placed into one of five filter tanks. More acid was added until a Ph of 3.5 to 4 was achieved. In these filter tanks, a vacuum system helped to suck the waste liquid away, leaving the vanadium granules on the mat. Now known as "red cake", the vanadium was next shoveled into a bin with a large fusion furnace at the bottom. At the beginning of each work shift the furnace was filled with vanadium and fired. Using scoop shovels, it took two men an hour to charge the furnace. As the red cake melted, it began to fuse with the acids that had been added in the filter tanks.

As the fused, molten, material puddled up in the bottom of the furnace, it was drained through a spigot onto a flaking machine. The flaking machine was a cast iron, water-enclosed, wheel approximately six feet in diameter. The wheel revolved horizontally below the spigot at the bottom of the fusion furnace.[119] When the molten liquid dropped from the spigot on to the water-cooled wheel, it instantly cooled and splattered into flakes on the wheel. This material - the final vanadium product, called vanadium pentoxide - was scraped off the wheel by a metal scraper and formed into 20-inch by 8-inch by 6-inch high cakes. The vanadium pentoxide was then sealed in 55-gallon steel drums and shipped from Naturita to Montrose by truck. From Montrose, the vanadium pentoxide was shipped by rail to Bridgeport, Pennsylvania, Cambridge, Ohio, or Keokuk, Iowa. It was then sold to various steel companies to be used as an alloy to give steel components greater tensile strength and elasticity.

The Sampling and Assaying Process at the Naturita Mill

In addition to the main processing operation, ore at the Naturita Mill was also sampled and assayed to determine its relative uranium and vanadium values. After the ore had been allotted a serial number, approximately ten percent was separated out to be sampled and assayed. As the ore was being shoveled into stockpiles, every tenth shovelful was placed in a wheelbarrow and was split off from the main ore body to be sampled and assayed. This ore was dumped onto a clean concrete pad where it was "coned and quartered." This involved thoroughly mixing the ore by hand and then cutting it into four equal portions with a shovel. Two of the quarters were put back with the main ore pile, while the other two quarters were set aside. The coning and quartering process was repeated several times, until forty to sixty pounds of ore had been separated out to be sampled and assayed. This material was then placed in a small sample crusher which reduced it to minus ½-inch mesh.

The ore was then run through a series of "cone splitters" (also known as divided splitters). As the ore went through each splitter, it was mixed together and divided into two equal portions. Each time it was divided, half of the ore was sent back to the main ore pile, while the other half was again put through a splitter. After passing through each splitter, the ore was also run through another, smaller, crusher that eventually reduced the ore to minus 1/8-inch mesh. This process was repeated until a two to three pound ore sample had been obtained for analysis. Coning and quartering the ore, and running it through the crushers and splitters, was intended to ensure that the analysis sample had been selected randomly and that it was representative of the main ore body that it had come from.

The ore that was to be analyzed was next put in a drying oven where it remained overnight. The following day it was pulverized to a flour-like consistency of minus 200-mesh, and then put through another, smaller, splitter, that again divided it into two equal portions. One half was thrown away, and the other half was divided into five portions and placed in envelopes. The envelopes were sealed with sealing wax and labeled with the lot number that had been assigned to that body of ore. One envelope was taken to the laboratory for analysis, one envelope was sent to the ore producer, one was sent to the AEC sampling plant in Grand Junction, and two envelopes were stored at the mill. The envelope of ore that was taken to the laboratory was dissolved with acids and chemically analyzed in an assay process to determine its vanadium and uranium values.

Uranium and Vanadium Concentrating at the VCA Naturita Mill 1960 - 1963

After shutting down in 1958, the Naturita Mill did not process any ore for more than two years. Then, in 1960, the VCA decided to reconstruct the Naturita Mill as an experimental uranium and vanadium ore concentrating facility. Prior to this time, the VCA was paying miners to ship raw ore to their Durango mill. By first concentrating the ore at Naturita, the company hoped to greatly reduce the volume of ore shipped to Durango, and correspondingly reduce the company's shipping costs. In the end, however, the cost to concentrate the ore at Naturita was greater than the savings gained by reducing the tonnage shipped to Durango. As a result, the concentrating facility was not in operation for long. It closed in early 1963.

Although the concentrating facility was in operation for only two years, nearly all of the extant buildings at the site were built in 1960 or 1961 for the concentrating process. Also circa 1960, in preparation for building the concentrating plant, much of the uranium and vanadium processing facilities were removed, and in 1958, two of the four salt roasters had been dismantled and moved to the VCA's Durango plant. Facilities removed at Naturita included a powerhouse and four wood-frame maintenance buildings (all located west of the roasters), a wood-frame ore crushing building located east of the roasters, and fusion furnaces and leach tanks located northeast of the dryer building.

Structures from the earlier era that were not razed included the mine and mill warehouses (Buildings H and J) and two brick Skinner salt roasters (Structures F and G). All other extant buildings and structures at the site were built as part of the concentrating facility during 1960 and 1961. These include the Office (Building A), Weighing Station and Office (Building B), Sampling Building and Ore Receiving Platform (Building C), the Grinder/Rod Mill (Building D), the Dryers (Building E), the Laboratory (Building I), the Mechanics Shed (Building K) and the Water Tower (Structure L). A building erected in 1960-1961 just east of the grinder/rod mill, and used to house thickener tanks and a "Peterson" filter process, was later razed.

The Concentrating and Assaying Processes 1961 - 1963

The concentrating of fresh crude ore at the Naturita Mill in the early 1960s involved a series of steps that eventually resulted in the production of uranium/vanadium concentrate in the form of dry marble-sized pellets. At the beginning of the process, a load of crude ore was received at the weighing station and scale platform where it was allotted a serial number identifying who produced it and where it had been mined. From there, the ore was moved to the ore receiving platform where it was put through an 8-inch mesh sorter known as a "grizzly." Any ore that was too large to pass through the grizzly had to be broken up by hand until it was small enough to fit through. The ore next dropped through a bin to a crusher where it was reduced to minus 1½-inch mesh. The ore was then moved by a magnetic conveyor[120] into the sampling building where it was dropped into bucket elevators carried by a conveyor belt.

Every tenth bucket was tripped so that a random ten percent of the ore was split off for chemical analysis. This ten percent of the ore was then put through a set of steel roll crushers and dropped into a second set of bucket elevators. Once again, every tenth bucket was tripped, and ten percent of this ore (one percent of the total ore pile) was split off and put through a 3/8", or smaller, mesh screen. Meanwhile, the remaining ore sample was routed back to rejoin the main ore pile. The small amount of ore that had gone through the 3/8", or smaller, mesh screen was then put in to a cone splitter, a device which separated the ore into two equal-sized and random samples. After being divided in the cone splitter, one-half of the ore sample was placed in a smaller crusher which reduced the ore to between 1/8" and 1/4" mesh. This ore was then put through another cone splitter. One-half of this split yielded an ore sample that weighed between two and five pounds. This was put in a pan and placed in a drying oven for twelve to sixteen hours.

The ore sample was brought out of the oven on the next day's shift and put through a disc pulverizer which reduced it to an extremely fine minus 200 mesh. This material then was put through yet another cone splitter. One-half of the ore that came out of this cone splitter was then placed in a belt-driven V-shaped blender, where it was thoroughly blended together for one-half hour. The ore sample was then taken from the blender and placed on a clean sheet of paper. After being rolled in the paper, the sample was divided into five equal portions and placed into five 2" by 5" envelopes.

Each envelope was labeled with the serial number that had been allotted to the ore at the scale platform. One envelope was taken to the laboratory, one envelope was sent to the ore producer, one was sent to the AEC in Grand Junction, and two envelopes were stored in cupboards in the mill warehouse. The envelope of ore that was taken to the laboratory was dissolved with acids and chemically analyzed in an assay process to determine its relative uranium and vanadium values. To guard against fraud, the chemical analysis was checked independently by two assayers whose results had to correlate. In addition, from the time the ore left the scale platform, it was identified only by its serial number, so that the assayers and persons involved in the splitting process did not know where the ore they were working with had come from or who had produced it. As a result, any potentially dishonest ore suppliers were prevented from corrupting the process by offering bribes to VCA employees in return for artificially inflating the value of their ore. On the whole, ore producers very rarely attempted to fraudulently inflate the value of their ore, and they were also generally satisfied that the VCA was not unfairly deflating the ore's value in the assay process.[121]

Apart from the ore that was split off for assaying, the main body of ore was transported from the sampling building to the concentration storage tanks in preparation for further processing. The ore was drawn from the underside of the concentration tanks into the grinder/rod mill where it was further crushed and passed through large stainless steel multiple agitation machines containing an acid and water mix. The values were then pumped into thickener tanks, while the byproducts were pumped to the tailings pile.

No longer standing, the thickener tanks were made of wood with a stainless steel conical bottom. They were approximately seventeen feet high and thirty feet in diameter. In these tanks, the ore was thickened in a settling process. From the bottom of the thickener tanks, the material was drawn through a Peterson filter process[122] which sucked off the excess liquid leaving a thick paste known as concentrate. Next, the concentrate was placed into one of three revolving dryers that were heated by natural gas burners. Appearing like large steel tubes, the dryers were approximately thirty feet long and eight or more feet in diameter. After one to two hours in the dryers, the concentrate emerged in the form of dry, marble-sized pellets. The final step of the concentrating process was to place the concentrate into large concrete storage bins. From there, it was picked up by a rubber-tired loader and deposited into trucks for transport to the VCA's mill at Durango.

The Naturita Mill Site as a Consolidation and Supply Center 1963 - 1978

Following the concentration process' closure in early 1963, VCA's Naturita facility never again milled or concentrated uranium or vanadium ore. Instead, Naturita was used primarily as a mining office and supply center where local ore producers continued to obtain mining equipment. Between 1963 and 1978, the facility was also utilized as a consolidation center as the VCA downsized its operations throughout the Colorado Plateau. During this period, VCA-owned mining and milling equipment was brought to Naturita from Durango (closed 1963), Marysville, Utah (closed circa 1964), Monument No. 2 (closed 1968), and Shiprock, New Mexico (closed 1978). At Naturita, equipment from these sites was sold off or liquidated for the best prices that could be obtained.

After VCA merged with Foote Mineral in 1967, the company's downsizing efforts on the Colorado Plateau were accelerated. A primary cause of these efforts was the discovery that ore tailings at steel refineries in the African Congo (Zaire) contained some twenty-five percent vanadium. By comparison, the ore processed at Naturita in the early 1960s contained, on average 1.23 percent vanadium. Both Foote Mineral and Union Carbide, obtained contracts to process the vanadium-rich African ore tailings. Foote Mineral-owned ore from the Congo was shipped to the Gulf of Mexico and brought by barge up the Mississippi and Ohio Rivers to mills located at Cambridge and Stubenville, Ohio and Keokuk, Iowa. On the Colorado Plateau, meanwhile, uranium and vanadium mining and milling stopped almost completely. Among the Foote Mineral (formerly VCA) owned mills, only the mill at Shiprock was still in operation after 1968. A decade later, it too finally closed.

The Uranium and Vanadium Industries and the Naturita Mill in the 1970s

By the early 1970s, most of the world-wide uranium production was being used to produce nuclear energy.[123] The Arab oil embargo and subsequent energy crisis in 1973 prompted a search for "alternative energy sources, including nuclear."[124] In 1974 the Grand Junction Office of the AEC[125] administered the National Uranium Resource Evaluation (NURE) program, a ten year assessment of uranium resources in the United States.[126] By 1978, uranium was selling for a startling $43.40 per pound, a significant increase over the $8.00 per pound price of 1968.[127] The AEC still offered leases for forty square miles of land in Colorado, Utah and New Mexico in 1974. Prior to 1986, these holdings produced 1.5 million tons of ore, including 5.9 million pounds of uranium and 30 million pounds of vanadium pentoxide. Other companies, including Union Carbide and Cotter Corporation continued to produce ores as well.[128]

The 1970s also saw new activity at the Naturita Mill site. In 1975, the Nuclear Division of General Electric leased a portion of the site from Foote Mineral to establish an ore buying station that functioned through the 1980s. The station served as a market to those miners who did not want to ship their ore to Union Carbide's Uravan station. Eventually, however, the ore purchased here was sold to Union Carbide.[129] In 1976 the Ranchers Exploration and Development Corporation bought the 24-acre portion of the Naturita site where the tailings had been kept. Ranchers Exploration began to remove the tailings and reprocess them at another facility approximately four miles south of the Naturita site.[130] Between 1977 and 1979, Ranchers Exploration moved the former Naturita tailings to a heap-leach processing plant with a capacity of 1200 tons per day.[131] Using improved technologies during these two years, 380,000 pounds of uranium and 1,840,000 tons of vanadium pentoxide were recovered from the former Naturita tailings.[132]

Issues of Safety and Clean-Up: 1940s - 1990s

The issue of mine safety on the Colorado Plateau has ostensibly been considered since the 1940s. At that time there were no federal controls for mine safety on the Colorado Plateau, but in 1948, Ralph Batie, chief of Health and Safety for the Colorado Raw Materials Office of the AEC, Jack Torrey of the Industrial Hygiene Section and Duncan Holaday, an expert on radiation-related industrial hygiene met in Grand Junction to discuss what they termed the "radiation threat" in local mines.[133] The AEC as a whole, though, avoided any direct involvement with safety issues, stating that they were the responsibility of the state.

Those most directly affected, the miners and millworkers, were not overly concerned with health and safety issues. They were making decent wages, and, on the whole, they were skeptical regarding potential health threats.[134] In fact, in the pre-World War II years, many miners and mill workers were particularly susceptible to a purveyors of quack remedies using radium and uranium products. Such items as radioactive salves, lotions, water, and other tonics were marketed as medications for a wide variety of ailments. Among other susceptible quack remedies, miners and millworkers wore sacks of high grade uranium around their necks to cure or prevent cancer of the throat, and drank water from bottles containing chunks of carnotite to alleviate rheumatism.[135] The scientific community, during this era, was well aware of the dangers (as well as the benefits) of radioactive materials. While scientists likely viewed such quack remedies with disdain, any attempts to educate the miners and millworkers in their dangers were usually rebuffed. In general, educating workers and the general populace about the dangers of radioactivity was a long-term process.

Subsequent health and safety studies eventually led to the adoption of a minimum standard for safe working conditions and companies began to institute some safety features, such as providing adequate ventilation. State and federal agencies, though, were reluctant to impose any strict regulations. In 1955, a "Seven-State Uranium Mining Conference on Health Hazards" was held in Utah leading to the adoption of minimum levels of radon acceptance. Most mining representatives stated that they would try to maintain that level but that they probably would not be able to.[136]

The Naturita Mill was one of many singled out for its poor safety features. A 1949 *Rocky Mountain News* article stated that the employees at the VCA plant at Naturita were exposed to radioactivity silicosis, poisonous gas fumes and countless other hazards.[137] In addition, chemists refined uranium with their bare hands and without masks, workers ate lunch in areas of radioactivity, and there were no changing facilities or physical check-ups. The article also alleged that radioactivity in the Naturita plant was five times the acceptable level, that free silica was three times the tolerance level, and hydrochloric acid was fifty times its acceptable level.[138]

The debate over safety in mines continued. In 1959 the Federal Radiation Council was established to develop a general policy for radiation protection. The Council was first introduced to the problem of radiation in the mines in 1960, when the governors of the four states involved in uranium mining were called to an emergency meeting. At the meeting, federal health official Dr. Harold J. Magnuson stated that lung cancer was found in miners at five times the normal rate. He also reinforced that proper ventilation was one method to manage radioactive contamination. The findings of this meeting were reported to the Federal Radiation Council, but they did not produce a study of the problems until 1965. It was entitled "Radiation Protection Policy: Guidance for Control of Radiation Hazards in Uranium Mining." The paper did little to change the conditions in the mines, however.[139] Not surprisingly, there was still a great deal of reluctance on the part of federal and state agencies to commit to stringent safety programs that would adversely affect the industry.

In 1962, another safety issue emerged when it was determined that mill tailings were radioactive and could possibly cause cancer.[140] In 1968, the AEC provided states the option of enforcing safety standards with uranium millings. Between 1962 and 1987, state and federal funds reaching $60 million were spent to clean up the tailings in Grand Junction, known once as the "city that glows in the dark." In previous years, builders and homeowners had routinely used fill from the nearby Climax Uranium Company Mill outside of Grand Junction as mortar between the bricks in homes, schools, and churches, as garden soil, and in backyard patios. Once the radioactivity of this fill was discovered, it became clear that a clean-up was necessary.[141]

In conjunction with the Colorado Department of Health, the Grand Junction Office oversaw the Grand Junction Remedial Action Program in 1972, the first of its kind in Mesa County.[142] The program expended $22.9 million to remove tailings from 593 buildings in Grand Junction. Then, in 1983, the Department of Energy instituted another remedial program to remove tailings from other parts of the community, such as lawns and sidewalks.[143] After Congress passed the Uranium Mill Tailings Radiation Control Act in 1978, other programs followed. By 1994, the Uranium Mill Tailings Remedial Action Project (UMTRAP) had overseen the cleanup of some 4000 homes and businesses in the Grand Junction vicinity.[144] In 1987, Colorado passed legislation requiring an environmental report concerning the intentions of milling operations with regard to waste disposal.[145]

In 1974, the AEC, Environmental Protection Agency (EPA) and Colorado Department of Health compiled a report on the conditions of the Naturita millsite and tailings pile. The purpose of the report was to determine if corrective action should be taken at the site. At the heart of the report was the mill tailings pile, which took up approximately 20 acres of land adjacent to the San Miguel River, well within the river's flood plain. When flooding occurred, tailings were dispersed down the river. The report concluded that three areas should be studied further: stabilization of the areas of the tailings pile that had eroded; construction of an earthen dike to separate tailings from the river and modify the river channel to divert the flow from the floodplain; and further examination of the site to determine radioactivity and provide recommendations for decontamination.[146] Earlier, during the fall of 1969 and winter of 1970, Foote Mineral and the Colorado Department of Health had endeavored to stabilize the tailings pile by covering it with top soil, fertilizing, seeding, and watering it until a root system took place.

Assessments conducted by Ford, Bacon and Davis Utah[147] in 1977 and 1981 studied problems related to the radioactive mill tailings at the Naturita site. Background for the first assessment began in 1976, when gamma levels of tailings holes, field surveys and radon measurements were completed. At the time of the assessment, 704,000 tons of tailings were present on the Naturita site. The assessment essentially covered soil characteristics, geology, hydrology and meteorology, windblown and water contaminants, radiation exposure to human beings, radon gas levels and direct gamma radiation. In addition, the report discussed health impacts, nonradioactive pollutants, the value of remaining tailings, and impacts on social elements and property values. Based on the findings the assessment proposed two options: "remedial action at off-site structures" (in Naturita and Nucla) and "remedial action at off-site structures and cleanup of windblown contamination surrounding the tailings site." The estimated costs of these options were $270,000.00 and $950,000.00 respectively.[148]

The 1981 assessment was contracted by the U.S. Department of Energy's Albuquerque office. Essentially a revision of the 1977 findings, this report became necessary once conditions at the Naturita site changed. In the interim, Ranchers Exploration and Development had removed some tailings at the Naturita site for reprocessing, but 344,000 tons of contaminated materials remained. This assessment addressed the same concerns as the 1977 report, except that it did not discuss possible valued tailings. Based on its findings, Ford, Bacon and Davis Utah suggested two new alternatives for the site: "stabilization of the site in its present location with the addition of three meters of stabilization cover material" or "removal of residual radioactive materials to a disposal site and decontamination of the Naturita site." Cost estimates for the two options were $7.2 million and $8.2 million respectively.[149]

In 1984 and 1985, Bendix Field Engineering Corporation for the U.S. Department of Energy conducted its own study of the Naturita site. The goal of this study was to determine the level of radon contamination that exceeded EPA and UMTRA standards. Working in conjunction with Jacobs Engineering Group, Bendix conducted a series of tests that included "background radiologic and geochemical data used to determine exposure rates, disequilibrium between radium and its radon daughters, moisture content in soils, and concentrations of radium, thorium and potassium in soils." In addition, the level of contamination around the former tailings pile was analyzed. This data was used to assess the extent of work to be done for the radiologic site characterization. That fieldwork was conducted in January and February of 1985.[150]

Finally, beginning in 1993 the Naturita Mill site became the focus of a Uranium Mill Tailings Remedial Action project. Sponsored by the Department of Energy in Albuquerque, the UMTRA project resulted in the site's reclamation during the summer and fall of 1994.[151]

Epilogue

Beginning with its first vanadium production in 1939, the Naturita Mill influenced regional and national events for nearly four decades. Locally, the mill was the Naturita's and Nucla's chief employer, thus it greatly affected the area's socioeconomic character. Reflecting the progression from radium to vanadium to uranium mining on the Colorado Plateau, the mill produced vanadium that was vital to the war effort, processed uranium for the Manhattan Project, and was an integral part of the Atomic Age that emerged after World War II.

Endnotes

1. W.L. Dare, R.A. Lindblom, and J.H. Soule, "Uranium Mining on the Colorado Plateau," Bureau of Mines, United States Department of the Interior, Information Circular 7726, September 1955, pp. 1, 5.

2. Ibid., p. 5.

3. Richard P. Fischer, "Vanadium Deposits of Colorado and Utah: A Preliminary Report," U.S. Department of the Interior, Geological Survey, Bulletin 936-P (Washington: U.S. Government Printing Office, 1942), p. 363.

4. R.P. Fischer, "Uranium-Bearing Sandstone Deposits of the Colorado Plateau," *Economic Geology and the Bulletin of the Society of Economic Geologists* Vol. 45, No. 1 (January-February 1950): p. 1; Dare, Lindblom, and Soule, p. 8.

5. *Used in this context, the term "ore" is defined as a natural combination of minerals from which a metal, or metals, can be extracted.*

6. Dare, Lindblom, and Soule, pp. 5, 8.

7. W.P. Huleatt, Scott W. Hazen, Jr., and William M. Traver, Jr., "Exploration of Vanadium Region of Western Colorado and Eastern Utah," Report of Investigations 3830, United States Department of the Interior, Bureau of Mines, September 1946, p. 1.

8. Wilson Rockwell, *Uncompahgre Country* (Denver: Sage Books, 1965), p. 147.

9. Doug Stewart, "Farming Town Rises and Falls with Economy: Naturita a Quiet Community that is Popular with Hunters," *Rocky Mountain News*, 30 August 1980, p. 78.

10. P.R. Steele, "Turbulent History of Naturita Recalled as Election Post Mortem," *Montrose Daily Press*, 25 April 1951, p. 1.

11. Rockwell, *Uncompahgre Country*, p. 150.

12. Ibid., pp. 147, 149.

13. Ellen Z. Peterson, "Origin of the Town of Nucla," *Colorado Magazine* Vol. 26, No. 4 (October 1949): p. 252; Rockwell, *Uncompahgre Country*, p. 166.

14. Rockwell, *Uncompahgre Country*, pp. 169-171.

[15]Robert G. Athearn, *The Coloradans* (Albuquerque: University of New Mexico Press, 1976), p. 202.

[16]Rockwell, *Uncompahgre Country*, pp. 150, 195, 201.

[17]Ibid., p, 195.

[18]A graduate of the Paris School of Mines, Charles Poulot, and his partner Charles Voilleque, conducted experiments in extracting vanadium and uranium oxides from carnotite ores. In the late 1890s, their laboratory was located at 3225 Champa Street, in Denver.

[19]Radium's effect on living cells was discovered somewhat by accident by French chemist Antoine Henri Becquerel in 1901. While making a visit to London, Becquerel carried a small vial of radium concentrates, given to him hy the Curies, in his pocket. "...two weeks later, an inflammation appeared on his skin where the radium had been, and soon a sore developed which required some time to heal. Pierre Curie repeated his experience, and estahlished definitely that the burn came from the radium." Over the next several years, other scientists conducted a series of studies "which revealed radium's power to alter life processes." See Gary Lee Shumway, "A History of Uranium Industry on the Colorado Plateau" (Ph.D. dissertation, University of Southern California, 1970), pp. 12-13.

[20]William L. Chenoweth, "The Radium Industry of Southwestern Colorado and Southeastern Utah, 1910-1925, with Emphasis on the Activities of Radium Luminous Materials Corporation / United States Radium Corporation," 2 Novemher 1990, p. 5.

[21]William L. Chenoweth, "Historical Review of Carnotite Mining in Southwestern Colorado." Report prepared for U.S. Bureau of Land Management, Septemher 1993," p. 7.

[22]Ihid., p. 10.

[23]Ibid.

[24]Ibid., pp. 1-2.

[25]Ihid.," pp. 13-16.

[26]There were essentially two ways to extract radium salts form carnotite ores: "direct-dissolution process" and "indirect-dissolution process." Direct-dissolution process involved the following: "Carnotite ore, after crushing, was placed in acid-proof hrick tanks, and treated with hydrochloric acid to dissolve the carnotite. The solution was then treated with sulfuric acid and harium chloride to precipitate harium as sulfate. Radium precipitated with barium as radium-barium sulfate (radioharite). The resulting liquor which contained

uranium and vanadium in solution and radium-harium sulfate in suspension was decanted through an opening in the side of the tank level at the top of the quartz sand tailings. In order to maintain the sulfates in solution the sand-liquor mixture had to be stirred. Radium-harium sulfate has a specific gravity of 4.5 so that it would settle in the tank rapidly if the mixture was not stirred. The radium-harium sulfate in the decanted solution was allowed to settle and the uranium-vanadium solution was removed. Most plants recovered the vanadium, hut the uranium was usually discarded into the sewers. The bed of tailings remaining in the tank was washed with water, stirred, and decanted again. The ore tailings were then conveyed to a dump. The separated radium-barium sulfate was then treated through a series of chemical procedures, involving sodium carbonate and hydrochloric acid, to produce the final product, "radium chloride." Indirect-dissolution process involves leaching the ground ore with a sodium bicarbonate solution to dissolve the uranium, which was removed in solution. The remaining solids were then boiled with hydrochloric acid before the sulfuric acid and harium chloride were added. The rest of the process is the same as that of direct-dissolution process. See Chenoweth, "Historical Review..." pp. 16-17.

27. Doug Stewart, "Farming Town Rises and Falls with Economy," *Rocky Mountain News*, 30 August 1980, p. 78.

28. Chenoweth, "Historical Review..." p. 8.

29. Rockwell, *Uncompahgre Country*, p. 199. Coke Ovens hecame the name of the site where coke ovens were utilized to make coke for the smelter at the Cashin Copper Mine around the turn of the century.

30. Chenoweth, "Historical Review..." pp. 8-9

31. Ihid., p. 11.

32. Ibid., p. 12.

33. Ihid., p. 20.

34. "Highlights in the History of Vanadium," *The Mining and Contracting Review* Vol. 42 (31 July 1942): p. 12.

35. Ibid., p. 13.

36. Later called Vanadium, Newmire was located west of Telluride in San Miguel County.

[37]Richard P. Fischer, J.C. Haff, and J.F. Rominger, "Vanadium Deposits Near Placerville, San Miguel County, Colorado," *Colorado Scientific Society Proceedings* Vol. 15, No. 3 (1947): p. 119-120.

[38]"Highlights in the History of Vanadium," pp. 12-13.

[39]Ibid.," p. 13.

[40]"Prospectus: Vanadium Corporation of America," Published by Kidder, Peabody & Company, 2 June 1954, p. 3. From the Colorado Historical Society's William S. Jackson Business Records Collection, Folder 148, Collection 1074.

[41]"Adventures in Industry: The Colorado Plateau," *The Vancoram Review* Vol. XIII, No. 1 (Summer 1957): p. 5.

[42]Vanadium was one of a number of metals that could be used as a steel alloy. Two others often used at the time were chromium and molybdenum. While vanadium may have been the best alloy for some applications, steel manufacturers often used whatever alloy could be obtained for the lowest cost. See Shumway, "A History of the Uranium Industry...," p. 95.

[43]"Highlights in the History of Vanadium," pp. 13-14.

[44]Chenoweth, "Historical Review..." p. 20.

[45]State Corporations: Domestic Corporation Lindex Microfilm, 1935-1965. Located at Colorado State Archives; "Highlights in the History of Vanadium," p. 14.

[46]"Highlights in the History of Vanadium," p. 14.

[47]Huleatt, et al, "Exploration of Vanadium Region..." p. 4.

[48]Chenoweth, "The Uranium-Vanadium Deposits of the Uravan Mineral Belt and Adjacent Areas, Colorado and Utah." New Mexico Geological Society Guidebook, 32nd Field Conference, Western Slope, Colorado, 1981," p. 168.

[49]There is conflicting information regarding how much ore the Naturita Mill processed each day. William L. Chenoweth states that after VCA rebuilt the Naturita Mill, it "began operating in 1940 at the rate of 100 tons per day." ("Historical Review of Carnotite Mining in Southwestern Colorado" pp. 20-21) A 1941 article from the *Rocky Mountain News*, however, states that VCA's mill "located about three miles from Naturita on the San Miguel River... is now treating about 50 tons of vanadium ore per day." (E.P. Arthur, "Development of New 'Salt' Process Paces Increased Vanadium Production," *Rocky*

Mountain News, 5 January 1941.

50. E.P. Arthur, "Development of New 'Salt' Process Paces Increased Vanadium Production," *Rocky Mountain News*, 5 January 1941.

51. James Keener, and Christine Bebee Keener, *Colorado Highway 141, Unaweep to Uravan: Travel Through 1.7 Billion Years Into the Atomic Age*. Grand Junction: Grand River Publishing, 1988, p. 40.

52. Chenoweth, "Historical Review..." p. 22.

53. Huleatt, et al, "Exploration of Vanadium Region..." p. 9.

54. Uranium had been discovered in Germany in 1789 where it was found in a black mineral called pitchblende. Prior to that time, a metal was known to exist in the pitchblende, but it was believed to be tungsten. Eventually geologist M.H. Klaproth determined that the metal was an unknown mineral and he gave it the name "uranium" for the planet Uranus. See L. Sanderson, "Uranium," *Canadian Mining Journal*, Vol. 60, No. 12 (December 1939): p. 816, and Charles F. Thomas, "Mining Uranium in the Colorado Plateau, Part I," *The Explosives Engineer*, Vol. 32, No. 5 (September-October 1954): p. 150.

55. William L. Chenoweth, "Raw Materials Activities of the Manhattan Project on the Colorado Plateau," March, 1985, p. 1. On file in the William L. Chenoweth Collection, Museum of Western Colorado, Grand Junction, Colorado.

56. Ibid.

57. Ibid., p. 2.

58. Ibid.

59. Ibid., p. 5.

60. William L. Chenoweth, "American Sources of Uranium Acquired by the Manhattan Project," United States Department of Energy, Grand Junction Area Office, Mineral Assessment Division, November 1982, p. 1.

61. Raye C. Ringholz, *Uranium Frenzy: Boom and Bust on the Colorado Plateau* (New York: W.W. Norton & Company, 1989), p. 27.

62. "Green sludge" was the term commonly used to describe the uranium product processed by the mills.

[63] William L. Chenoweth, "Raw Materials Activities of the Manhattan Project...," p.1.

[64] Correspondence from Philip Leahy to William Chenoweth, 15 December 1986.

[65] Chenoweth, "Historical Review..." p. 25.

[66] James Keener, and Christine Bebee Keener, *Colorado Highway 141, Unaweep to Uravan...*, pp. 40, 42.

[67] F.F. Kett, "Naturita - Then and Now," *Vancoram Review*. 4:2 (Spring 1945), p. 18.

[68] In 1930, VCA had advanced approximately $427,000.00 to Rare Metals Company to finish construction on the Naturita Mill and to open carnotite mines near Naturita. As collateral for the loan, VCA held a mortgage on the Naturita facility, and when Rare Metals failed in the mid-1930s, VCA foreclosed. Thus by 1939, VCA was the sole owner of the Naturita Mill. See Shumway, "A History of the Uranium Industry...," pp. 99-100.

[69] Once all of the equipment and technology to process uranium had been installed at the mill, this was referred to as having a "uranium circuit" in place. Previously, only a "vanadium circuit" had been in place.

[70] "Report on Conditions of Uranium Millsite and Tailings Near Naturita, Colorado," 21 August 1974. Located at the Department of Energy, Grand Junctions Project Office, Chem-Nuclear Geotech.

[71] Chenoweth, "Historical Review..." p. 24-25.

[72] Kett, "Naturita: Then and Now," p. 18.

[73] Oral Interviews with Alfred "Buddy" Curtis and Leonard "Pat" Daniels, by Carl McWilliams, 10 September 1994, Nucla, Colorado.

[74] "Pattern, Organization of AEC at Grand Junction," *Uranium Information Digest*, Vol. 2, No. 9 (September 1955): p. 10; Holger Albrethsen, Jr. and Frank E. McGinley, "Summary History of Domestic Uranium Procurement Under U.S. Atomic Energy Commission Contracts," prepared for the U.S. Department of Energy Assistant Secretary for Nuclear Energy, Grand Junction Area Office, Colorado, September 1982.

[75] Charles F. Thomas, "Mining Uranium in the Colorado Plateau, Part I." *The Explosives Engineer*, 32:5 (September-October 1954), p. 150.

[76] Edwin Diamond, "Atomic Power Will Grow Bigger Lettuce, Run More Machines Better, Says Prominent Physicist," *Uranium Information Digest*, Vol. 2, No. 2, (February

1955): pp. 22-23.

[77]The Manhattan Engineer District became the Atomic Energy Commission (AEC) by Executive Order 9816 on January 1, 1947. See William L. Chenoweth, "Historical Review...", p. 28.

[78]The Colorado Raw Materials Office (CRMO) of the AEC was located in Grand Junction. The main office of the Division of Raw Materials was in Washington D.C.

[79]"Pattern, Organization of AEC at Grand Junction," *Uranium Information Digest*, Vol. 2, No. 9 (September 1955): p. 10; Holger Albrethsen, Jr. and Frank E. McGinley, "Summary History of Domestic Uranium Procurement Under U.S. Atomic Energy Commission Contracts," prepared for the U.S. Department of Energy Assistant Secretary for Nuclear Energy, Grand Junction Area Office, Colorado, September 1982.

[80]"Pattern, Organization of AEC at Grand Junction," p. 10. Now a component of the U.S. Department of Energy, in 1994 the Grand Junction Projects Office is still in operation at its original site.

[81]Charles F. Thomas, "Mining Uranium in the Colorado Plateau," *The Explosives Engineer*, Vol. 32, No. 6 (November-December 1954): p. 178.

[82]Albrethsen and McGinley,, "Summary History..." p. 4.

[83]Ibid., p. 8.

[84]Chenoweth, "Historical Review..." p. 29.

[85]Albrethsen and McGinley, "Summary History..." p. 7.

[86]One such article was Paul Leach's "Uranium Ore: How to Go About Finding and Mining It," (*Engineering and Mining Journal*, Vol. 149 (September 1948): pp. 75-76. In it Leach answered frequently asked questions regarding the uranium industry, explained where to sell the ore, how to find and recognize the ore, prices for ore and how to use a geiger counter.

[87]"Colorado Plateau Uranium Population Doubles in 2 Years," *Denver Post*, 6 February 1955.

[88]"History's Greatest Metal Hunt," *Life Magazine*, 23 May 1955, pp. 25-26.

[89]Ibid., pp. 26, 30.

90. Uranium Ore Producers Association Subscription form, March 1955. Museum of Western Colorado, Grand Junction, Colorado.

91. R & W Trailer Sales Advertisement. no date. Museum of Western Colorado, Grand Junction, Colorado.

92. W.T. Little, "A New Magic Word That's Brought Wealth to Colorado's Western Slope: Uranium," *Colorado Wonderland*, February 1955, p. 16.

93. Robert Casey, "Grand Junction Capital of Uranium Hunters: City Growing at a Rapid Pace," *Grand Junction Daily Sentinel*, n.d. *Grand Junction Daily Sentinel* Collections Clippings, 1954-1957. Museum of Western Colorado, Grand Junction, Colorado.

94. "Colorado Plateau Uranium Population Doubles in 2 Years," *Denver Post*, 6 February 1955.

95. "Adjusting to A-Boom Easy for Company-Owned Uravan," *Denver Post*, 17 November 1954.

96. ""Turbulent History of Naturita Recalled as Election Post Mortem," *Montrose Daily Press*, 25 April 1951; "Uranium Industry Boosts Naturita Population from 30 to 1,200," *Denver Post*, 16 November 1954.

97. "Naturita Booms Along With Uranium Industry Growth," [Grand Junction] *Daily Sentinel*, May 1955.

98. Albrethsen and McGinley, "Summary History..." p. A-24; draft contract No. AT-30-1-GEN-121 between the United States of America and the Vanadium Corporation of America, 24 March 1952, located at Department of Energy, Grand Junction Projects Office, Chem-Nuclear Geo-Tech, Grand Junction, Colorado.

99. According to written notes furnished by former VCA Naturita Mill Superintendent Leonard (Pat) Daniels, the surplus vanadium concentrate was generated by the sale of uranium concentrate to the AEC. This vanadium was not marketable by the VCA, and therefore, the AEC agreed to buy it at a negotiated price.

100.

101. Vanadium Corporation of America Thirty-Second Annual Report, 1951, p. 7. William S. Jackson Business Records Collection, Folder 148, Collection 1074, Colorado Historical Society, Denver, Colorado.

102. Letter to Stockholders, Vanadium Corporation of America, 29 April 1955. William S. Jackson Business Records Collection, Folder 148, Collection 1074, Colorado Historical Society, Denver, Colorado.

103. Chenoweth, "Historical Review..." p. 47.

104. Vanadium Corporation of America Annual Report, 1956, pp. 6, 9. William S. Jackson Business Records Collection, Folder 148, Collection 1074. Colorado Historical Society, Denver, Colorado.

105. Vanadium Corporation of America Annual Report, 1957, p. 4. William S. Jackson Business Records Collection, Folder 148, Collection 1074. Colorado Historical Society, Denver, Colorado.

106. Vanadium Corporation of America Annual Report, 1958, pp. 3-5, 8. William S. Jackson Business Records Collection, Folder 148, Collection 1074. Colorado Historical Society, Denver, Colorado.

107. Correspondence between G.W. Juteson, Acting Regional Director, PBS, to Willis Barnes, 17 July 1958. Department of Energy, Grand Junction Projects Office, Chem-Nuclear Geo-Tech.

108. Albrethsen and McGinley, "Summary History..." p. 5.

109. As quoted by Jesse C. Johnson, Director, Division of Raw Materials, U.S. Atomic Energy Commission at the 4th Annual Conference of the Atomic Industrial Forum in New York City, 28 October 1957, in Albrethsen and McGinley, "Summary History..." p. 5.

110. Taken from an announcement dated 21 November 1958 and released on 24 November 1958. In Albrethsen and McGinley, "Summary History..." p. 5.

111. Detailed information regarding the vanadium and uranium processing was obtained in oral interviews with former Naturita Mill Superintendent, Leonard "Pat" Daniels, and former VCA employee Alfred "Buddy" Curtis. Corroborating information was obtained from Robert C. Merritt's "The Extractive Metallurgy of Uranium," prepared under contract with the United States Atomic Energy Commission, Colorado School of Mines Research Institute, 1971.

112. Ore brought to the mill to be processed was commonly referred to as "millfeed."

113. Albrethsen and McGinley, "Summary History..." p. A-24.

[114]Among other factors relative to the ore's consistency, it was important that its lime content not be too high or too low. Otherwise, the ore would not react properly in the later stages of the milling process,

[115]A measurement of minus ½-inch mesh means that the individual granules of ore have a diameter of ½-inch or less.

[116]The rod mill at Naturita was comprised of a series of steel rods, three inches in diameter, and approximately six feet in length. The rods were turned by large, gear-driven, trunnions.

[117]Used either as a noun or verb, the term raffle means "rake."

[118]Used here, the term "fusion," from the root word "fuse", means to join together by melting.

[119]The flaking machine at the Naturita Mill was designed and built by VCA, but it was patterned after the "Burwell" designed flaking machine that was commonly employed at uranium and vanadium mills.

[120]The conveyor was magnetized to hold back a variety of metal objects that had inadvertently found their way into the ore at the mine. Such items as nails, bolts, screws, and even hammers and wrenches were routinely caught by the magnetic conveyor.

[121]Former VCA employee Alfred (Buddy) Curtis could recall only one occasion when an ore producer had unsuccessfully attempted to "salt" its ore at the ore receiving platform.

[122]Former VCA employee Alfred (Buddy) Curtis related that Peterson was the name of the company that manufactured the filter, and that it was generally referred to as a "Peterson filter." He described the filter as a large multi-disced band, made of wood, and covered with nylon filter cloths. As the filter discs revolved, a vacuum process first sucked and then blew the ore against rubber scrapers which removed the slime in the upper rear portion of the filter. An auger then pushed the remaining ore material into the dryers.

[123]Chenoweth, "Historical Review..." p. 41.

[124]Alan Gersten, "Uranium: A State Force Since Marie Curie," *Rocky Mountain News*, 9 July 1978, p. 6.

[125]On January 19, 1975, the Atomic Energy Commission became the Energy Research and Development Administration (ERDA). On October 1, 1977, ERDA was

renamed the Department of Energy (DOE).

126."Serving Our Nation Since 1943: 50th Anniversary GJPO," p. 6. United States Department of Energy, Grand Junction Projects Office.

127.Ibid.

128.Chenoweth,"Historical Review..." p. 43; Gersten, "Uranium: A State Force..."

129.Chenoweth, "Historical Review..." p. 44; "Uranium Mill Tailings Tour: Grand Junction, Colorado to Naturita, Colorado via Unaweep Canyon," Report prepared for Field Trip Technical Measurements Center Workshop, 29 July 1983, p. 7.

130.Robert A. Showalter, Bendix Field Engineering Corporation, Grand Junction, Colorado, "Radiological Characterization of the Naturita, Colorado Uranium Mill Tailings Remedial Action Site," June 1985, p. 3 (U.S. Department of Energy, Uranium Mill Tailings Remedial Action Project Office, Albuquerque Operations Office with U.S. Department of Energy, Grand Junction Projects Office, Grand Junction, Colorado.

131.Ford, Bacon & Davis Utah Incorporated, "Engineering Assessment of Inactive Uranium Mill Tailings Naturita Site, Naturita, Colorado," United States Department of Energy, Albuquerque Operations Office, Uranium Mill Tailings Remedial Actions Project Office, Albuquerque, New Mexico, July 1981, p. 2-2.

132.Chenoweth, "Historical Review..." p. 44.

133.Ringholz, *Uranium Frenzy*, p. 37-43.

134.Ibid., pp. 46-47, 86.

135.See Shumway, "A History of the Uranium Industry...," pp. 81-82.

136.Ibid., pp. 168-178.

137."Modern Forty-Niners on the Colorado Plateau: Can They Strike it Rich?" *Rocky Mountain News*, 21 August 1949, p. 2.

138.Ibid.

139.Ringholz, *Uranium Frenzy*, p. 237.

140."Cleanup of Uranium Boosts Economy but 'Glowing' Stigma Persists," *Rocky Mountain News*, 6 September 1987, p. 30.

141. "Cleanup of Uranium Boosts Economy..."

142. "Serving Our Nation Since 1943..." p. 8.

143. Ibid.

144. Ibid., p. 9.

145. Gersten, "Uranium: A State Force...," p. 6.

146. Ibid., pp. 1-3, 6.

147. "Ford, Bacon and Davis Utah Inc." is a Salt Lake City, Utah based engineering consulting firm.

148. Ford, Bacon & Davis Utah Incorporated, *Summary of Phase II - Title I Engineering Assessment of Inactive Uranium Mill Tailings, Naturita Site, Naturita, Colorado* (United States Department of Energy, Grand Junction, Colorado, November 1977), GJT-8S.

149. Ford, Bacon & Davis Incorporated, *Engineering Assessment of Inactive Uranium Mill Tailings*. (United States Department of Energy, Grand Junction, Colorado, November 1977), GJT-8S.

150. Showalter, "Radiological Characterization of the Naturita, Colorado Uranium Mill Tailings Remedial Action Site."

151. Morris Knudsen Corporation Environmental Services Division, "Uranium Mill Tailings Remedial Action Project (UMTRAP) Naturita, Colorado, Main Subcontract NAT-II, Information for Bidders, Final Design for Construction, Volume V," January 1994. United States Department of Energy, Albuquerque, New Mexico.

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